

ON THE ANATOMY OF *MULLERIA DALYI*, SMITH.

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Read 15th April, 1898.

THE animals (two in number) upon which these observations are based were discovered by Mr. Hubert Bonner, a relative of Mr. E. L. Layard, C.M.G., and forwarded to Mr. E. A. Smith, who described them under the name of *Mulleria Dalyi*.¹ I have to thank both Mr. Layard and Mr. Smith for giving me the opportunity of examining this interesting Lamellibranch.

So far as I am aware, the anatomy of the type-species of the genus, viz. *M. lobata*, is quite unknown, and we are but little better acquainted with regard to that of the allied genus *Ætheria*. Our knowledge of the latter rests mainly upon the observations of Rang and Caillaud,² who described, among the macroscopic characters, the relations of the muscles, the mantle, the gills, and the foot. Deshayes³ also gives a brief account, which is evidently taken from that of Rang & Caillaud. Finally, Mr. Smith has briefly described the more obvious features in the external form of *Mulleria Dalyi*. Some important points, however, still remain for me to describe in its anatomy, notably the minute structure of the gills, upon which the classification of the Lamellibranchs is now generally based.

The Mantle and Muscular System.—The mantle folds are almost completely separated from one another, being united at two points only, viz., at the posterior attachment of the gills, thus separating an inhalent from an exhalent orifice, and dorsally from the posterior end of the hinge-line for about one-quarter of the distance between this point and the attachment of the gills. The margins of the mantle below the attachment of the gills are beset with small sensory papillæ for a space which occupies about one-quarter of the extent of the mantle-margin from the attachment of the gills to the anterior hinge-line. In *Ætheria* similar papillæ occur all round the margin of the branchial chamber, and the mantle lobes are said to be completely disunited.

The single adductor muscle (Fig. I, *p.a.*) of the adult corresponds to the *posterior adductor* of dimyarians, and is situated just below and well behind the centre of the animal. In the young individual, according to D'Orbigny, two adductor muscles are present, and the shell is said to be anodontiform.

When a comparison is made between the single adductor muscle in *Mulleria* and in *Ostrea*, it is at once apparent that in the former it is very much smaller when compared to the size of the animal than in the latter, that it does not extend so far ventrally, and that it is

¹ Ante, p. 14.

² Mem. Mus. Hist. Nat. Paris, sér. III, tom. iii (1834), p. 143.

³ Lamarck, Anim. sans Vert., 2nd ed., tom. vi (1836), pp. 591-6.

not divided into two portions as it is in *Ostrea*, where we find one part composed of smooth, and the other of striated fibres.

A small *posterior pedal retractor* (*p.r.*) is present in *Mulleria*, situated immediately above, or anterior to the posterior adductor, and exhibiting



FIG. I.—General view, somewhat diagrammatic, of the anatomy of *Mulleria Dalzi*.

- a.* anus; *au.* left auricle; *c.g.* cerebral ganglion; *g.* gills; *g.d.* genital duct; *g.g.* genital gland; *int.* intestine; *k.* kidney; *l.* digestive gland; *l.p.* inner labial palp; *m.* mouth; *p.a.* posterior adductor muscle; *pc.* pericardium; *p.g.* pedal ganglion; *p.r.* posterior retractor pedis muscle; *p.v.* parieto-visceral ganglion; *r.* rectum; *r.o.* renal opening; *r.p.* reno-pericardial aperture; *st.* stomach; *t.* typhlosole; *v.* ventricle.

the typical relations of that muscle to the organ of Bojanus and to the nerve-cords.

The Mantle Cavity.—The branchial cavity is large and entirely open below. The supra-branchial (anal) chamber opens posteriorly by a wide slit: it consists of a large median chamber behind the posterior adductor muscle, where it receives the opening of the anus. Under

the adductor this chamber becomes divided into three by the union of the primary branchial filaments with the body-wall on either side. Still further forward, the middle of these three chambers becomes divided by the intervention of the visceral mass. In the relationship of this cavity to the surrounding parts, *Mulleria* resembles typical Eulamellibranchiata; there is, however, no communication, other than through the gill-slits, between the branchial and supra-branchial cavities, such as we meet with in a form like *Anodonta*.

The external apertures of the organ of Bojanus (*r.o.*), and of the genital gland, open into the innermost subdivision of the supra-branchial cavity.

The Foot and Visceral Mass.—The muscular foot present in most lamellibranchiata is entirely wanting in *Mulleria*, a condition which is correlated with the fixed mode of life of this form. *Aetheria*, on the other hand, although fixed, is stated to possess a large, thick, and powerful foot.¹ This form, however, still retains the two adductor muscles, and is evidently less modified than *Mulleria*.

The visceral mass is small and slightly bilobed posteriorly; it exhibits a few superficial muscular fibres mainly connected with the posterior pedal retractor.

The Labial Palps.—Two pairs of very small leaf-shaped labial palps are present; they are equal in size, and exhibit oblique ridges on the apposed surfaces. The inner pair unite below the mouth to form the lower lip, while the outer pair, which become slightly expanded anteriorly, unite above the mouth.

The Respiratory and Circulatory Systems.—The gills of *Mulleria* consist of two lamellæ on either side of the body; of these the outer is slightly the smaller. Their relations to each other, to the mantle

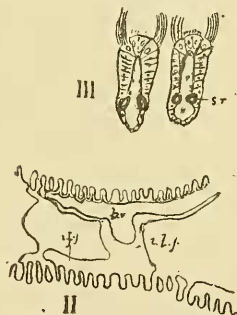


FIG. II.—Section across the gill lamella, cutting the gill filaments (*g.f.*) transversely; *b.v.*, blood-vessel; *i.f.j.*, interfilamental junctions; *i.l.j.*, interlamellar junctions.

„ III.—Transverse section across two gill filaments; *s.r.*, supporting rods.

¹ An examination of Rang & Caillaud's figure has caused some doubt to arise in my mind, whether *Aetheria* really possesses a muscular foot distinct from the visceral mass. S. P. Woodward, in his *Manual of Mollusca*, states (p. 276; 4th ed., p. 435) that there is no trace of a foot.

and to the body-wall, are those of a *typical Eulamellibranch*. The same is true of their more intimate structure, for an examination of sections under the microscope reveals the fact that the two halves of each gill lamella are connected together by vascular interlamellar junctions, and that the gill filaments themselves are further similarly united (Fig. II, *i.l.j.* and *i.f.j.*). In the individual filaments we find a supporting tissue, and firmer supporting rods (Fig. III, *s.r.*) are present. The whole structure recalls in its most minute details that of the gills of *Anodonta* or *Unio*.

The heart consists of a muscular ventricle (*v.*) and two thin-walled auricles (*au.*), the former giving origin to an anterior and a posterior aorta, the whole being enclosed in a fairly spacious pericardium (*pc.*). A mass of brown tissue forms the side walls of the pericardium anteriorly; this evidently represents Keber's organ.

The most striking feature seen in connection with the heart is the fact that the ventricle is not perforated by the rectum, but is situated some little distance below the latter, being separated from it by a portion of the genital gland. The pericardium, moreover, does not surround the rectum as in *Anodonta*, its roof being formed by the thick mass of the genital gland, within which the rectum lies embedded.

This non-perforation of the ventricle by the rectum is a very striking and peculiar feature, and one that is only met with elsewhere in such monomyarian forms as *Meleagrina*, *Ostrea*, *Anomia*, and *Pecten*; while among the dimyarians it is found in *Nucula*, *Arca*, and *Teredo*.

The fact that *Mulleria* is a sedentary monomyarian, and that it, at the first rough glance, recalls an oyster, suggests perhaps that the non-perforation of the heart by the rectum has some phylogenetic significance which further connects these two forms. A careful consideration, however, of the other anatomical features in the two genera, such as the structure of the gills, the relations of the kidney and genital ducts, shows that this cannot be the case. In this connection it is interesting to read the account given by Lang,¹ who, not knowing of the condition in *Mulleria*, explains the separation of the heart from the rectum as due to the increasing distance between the base of the gills and the original position of the heart, brought about by the shifting forwards of the enlarging posterior adductor muscle. The truth of this interpretation is rendered evident by an examination of such heteromyarians as *Pinna*, *Avicula*, and *Perna*, in which the consecutive stages in the separation of the heart from the rectum, leading up to the complete displacement found in *Ostrea*, may be seen.

One may, I believe, justly conclude that the same process has taken place in *Mulleria*, and thus regard the independently acquired monomyarian condition of this genus as responsible for the separation of the heart from the rectum. That the ventricle is not so distantly removed, nor the whole heart so much elongated, as in *Ostrea*, may be explained by the fact that in *Mulleria* the single adductor muscle is smaller, and has not migrated so far forward as in *Ostrea*.

¹ Lang, Text-Book of Comparative Anatomy, English edit., part ii, p. 206.

In conclusion, on this point we may safely state that the similar condition of the heart observed in *Ostrea* and *Mulleria* has been brought about by the action of similar causes possibly induced by a similar habitus, it being an example of what is known as convergence, and having no phylogenetic significance.

The Kidney or Organ of Bojanus.—The kidney calls for no special comment; it is essentially that of a typical Eulamellibranch, and closely resembles that of *Anodonta* in every detail.

The Genital Organs.—A large genital duct (*g.a.*) opens close to, but perfectly independent of, the external opening of the kidney in the supra-branchial chamber. The genital gland is extensive; it surrounds the coils of the intestine, and even extends round the rectum above the pericardium.

The Alimentary Canal.—The mouth practically leads direct into the stomach, an oesophagus, as such, not being present. The digestive glands are situated below and at the sides of the stomach, into which they open. There is no crystalline style or 'flèche tricuspid.' The intestine is fairly long and bent on itself several times: before leaving the visceral mass it enlarges abruptly; this point evidently represents the junction of the mid-gut with the hind-gut. The latter passes dorsally and continues to enlarge, becoming considerably dilated just in front of the heart; from this point it runs posteriorly, and gradually diminishes in size, finally opening into the supra-branchial chamber above the adductor muscle. The hind-gut is characterized by the possession of a longitudinal infolding of its ventral wall, forming what is known as a typhlosole (*t.*).

The Nervous System.—The only point of interest connected with the nerves is the presence of well-developed pedal ganglia; this, in face of the entire suppression of the foot, suggests that the latter has only recently been aborted. The cerebro-pedal commissures are, however, somewhat short. Owing to the great transverse width of the mouth, the cerebral ganglia are widely separated, and their transverse connective is consequently long.

Conclusions.—In the structure of its gills, of its kidney, and in the relationships of the urinary and genital ducts, *Mulleria* is a typical Eulamellibranch, but owing to its specialized mode of life it has undergone several striking changes. With the loss of locomotion the foot has atrophied, and apparently also in connection with the fixed habit the anterior adductor muscle, present in the young, has disappeared, and the posterior enlarged. This enlargement has brought about that Ostrean character, the separation of the heart from the rectum.

In its general organization, and especially in the details of the gills, the mantle lobes, and the kidney, *Mulleria* approximates to the Unionidæ; and the conclusion which I should arrive at from a study of the soft parts of this mollusc would be in entire accord with those already advanced by conchologists from a study of the shell, viz.: that *Mulleria* is closely related to the Unionidæ, but is extremely specialized in accordance with the fixed mode of life which it has adopted.